I 536.

32/6

*The Dibner Library
of the History of
Science and Technology*

SMITHSONIAN INSTITUTION LIBRARIES

A
DESCRIPTION
OF A
NEW INSTRUMENT
OR
CELESTIAL COMPASS,
&c. &c.

To Ensign M^r. Intosh Esq^r
with the Authors Compliments
and affectionate Regards

A

DESCRIPTION

OF A
Patent
NEW INSTRUMENT

OR

CELESTIAL COMPASS,

ADAPTED FOR ASCERTAINING

THE LATITUDE AND LONGITUDE AT SEA,

BY MEANS OF

THE DECLINATION AND RIGHT ASCENSION OF THE
HEAVENLY BODIES;

FOR FINDING THE DEVIATION OF THE MAGNETIC
NEEDLE, BY SIMPLE INSPECTION, IN ANY
PART OF THE WORLD;

AS ALSO,

FOR TAKING BEARINGS AND SURVEYING
WITHOUT MAGNETIC AID.

INVENTED BY

GEORGE GRAYDON,

CAPTAIN IN THE CORPS OF ROYAL ENGINEERS.

LONDON:

PRINTED BY S. AND R. BENTLEY, DORSET STREET.

1825.

2
99
13
25
5
AAH

TO

FIELD MARSHAL HIS GRACE

THE DUKE OF WELLINGTON, K.G., G.C.B.

&c. &c. &c.

MASTER GENERAL OF THE ORDNANCE,

COLONEL IN CHIEF OF THE CORPS OF ROYAL ENGINEERS,

THE FOLLOWING WORK

IS

WITH GREAT RESPECT

JUSTLY INSCRIBED,

BY HIS GRACE'S

MOST OBEDIENT HUMBLE SERVANT,

GEORGE GRAYDON.

GENERAL DESCRIPTION
OF THE
CELESTIAL COMPASS.

THIS instrument is denominated a Celestial Compass, from its capability of indicating the positions of the Heavenly Bodies relatively with the planes of the Meridian and Equinoctial Circles.

Three different constructions of the Celestial Compass are represented by the drawings subjoined.

FIGURE I.—PLATE I.

Represents the instrument adapted for determining the Longitude from the Moon's right ascension,* calculated from her horary angle and declination; which is found by inspection, by means of the Pole Star, or any other known fixed Star.

* Having obtained the Moon's right ascension at the place of observation, the time when the same quantity of right ascension takes place at Greenwich is readily found, by a simple proportion, from the Nautical Almanack; and, taking the difference between the time at Greenwich thus found, and the corresponding time at the place of observation, the Longitude may be determined.

This is effected by means of two reflecting mirrors differently inclined to the planes of the meridian and Equinoctial Circles, according to the declinations of the objects and their horary angles or distances from the plane of the meridian ;* so that the ray of reflection of each object, shall unite with the visual line in the centre of a fixed telescope : thus, reducing, as it were, to the plane of the equinoctial, stars of any degree of declination.

This method of determining the Longitude from the Moon's right ascension, is not liable to the practical difficulties and long calculations attending the present mode of finding it by means of the angular distance of the Heavenly bodies ; and, as the change of the Moon's right ascension for any given time, is generally much greater than the change of her angular distance from the Sun or a fixed Star, during the same time,† a comparison of the relative times under two different meridians may be made with more accuracy from the Moon's right ascension. The preference seems to be therefore due to this method, especially as this greater change of right ascension happens about the time of the Equinox, when precision of calculation at sea is most important.

Of course, in this as well as in all other cases of finding the Longitude, the apparent time at the place

* For the demonstration of the principle upon which the instrument is constructed, see Appendix, No. I.

† For a comparative statement of the change of the Moon's right ascension, and her angular distance in a given time, see Appendix, No. V.

of observation must be previously ascertained;* the corresponding Greenwich time may then be determined from the Moon's right ascension, which is found by means of the observed meridian distance and declinations of the objects as abovementioned.

DESCRIPTION OF FIGURE I.—PLATE I.

The circular plate A B is provided with two pillars or axes, *o p*, which are capable of revolving steadily in sockets in a direction perpendicular to the plate A B.

The lower parts of the pillars *o* and *p* are furnished with limbs and verniers, *q* and *r*, adapted to read off the degrees upon the divided arc, Q and R; and the upper parts of the pillars *o* and *p* are formed to a square fork or open frame, and are each provided with a reflecting glass, O and P, which are adapted to turn upon small axes or pivots, passing through the sides of the open frames in a direction parallel to the face of the plate. The outer ends of these small axes are each provided with a limb, *s* and *t*, carrying the graduated arcs or sectors, S and T, which are furnished with verniers, *v* and *w*.

* The apparent time at the place of observation is generally found from an altitude of the Sun or of a Star; but when an altitude cannot be taken, in consequence of the horizon being obscured, the apparent time at the place of observation may be found from the observed *meridian distance* of a fixed Star—which observed meridian distance may be obtained in the same manner as that of the Moon. See a description of the method of using the instrument, which follows.

Another mode of placing the instrument in its Equatorial position by the Pole Star, may be effected by means of the upper pointer in Ursa Major, or any other Star having the same right ascension.

The reflecting mirror *O* is only partially silvered, and the remaining portion is left transparent; at the same time the mirror *P* is silvered over its whole surface. This last-mentioned mirror is mounted in a small interior frame, which is adapted to turn upon secondary pivots in the frame which is connected with the limb *t* by the pivot or small axis abovementioned. By this means the mirror *P* has the liberty of motion in both directions, horizontally as well as vertically, upon its pillar or axis *p*: these motions become necessary in making observations with those Stars which have a considerable degree of declination.

The secondary motion of the pillar *p* is effected by a small worm wheel *x*, which has a screw engaging with it, furnished with a micrometer head *n*, by which the angle or extent of the side-inclination may be determined. *W* represents a short telescope, which is supported by a pillar rising from the circular plate *A B*. Its axis is placed correctly in a line with the centre of the two mirrors *O* and *P*, which line is parallel to the plate *A B*, and in a line over the meridian or noon hour line; so that the reflected images of the Sun and Moon, or the Moon and Star, when they fall on the mirrors, may be viewed through the telescope, to ascertain when the coincidence of the images takes place.

The graduated arcs *Q* and *R*, are divided into half degrees, or with twenty-four hours in the circle, and also the arcs of declination, *S* and *T*, in consequence of reflecting glasses being used.

METHOD OF USING THE INSTRUMENT.

See Figure I. Plate I.

In order to ascertain the Moon's meridian distance and declination, the instrument must be placed North and South, which is thus performed: The mirror P is to be inclined horizontally and vertically, as above described, according to the declination and meridian distance of any known fixed Star. The instrument is then to be held in the hand by the handle represented in the drawing, and moved so as that the reflected image of the Star may be viewed through the telescope; then will the visual ray or axis of the telescope, as well as the noon hour line, A B, coincide with the plane of the true meridian; because the incidental ray coincides with the bearing of the Star, both with regard to the meridian and Equinoctial circles. Of course the instrument will then be in-its true position, relatively with the Celestial sphere, in which position the bearing or place of any of the other Heavenly bodies may be determined, by inclining the mirror O horizontally and vertically, until the coincidence of the images takes place, as above described: then will the meridian distance of the object be shewn upon the graduated arc Q, and its declination upon the arc S.

For example: Let the divided arc T be set by its vernier *w* to the angle of declination of a known fixed Star, the Pole Star for instance (as its apparent motion is the slowest,) or $88^{\circ} 20' 54''$. Let the vernier *r* be set

to such division upon the arc R as will correspond with the meridian distance* of the same Star, suppose 20° . This being done, the instrument is to be moved in the hand either way, until the reflected image of the Star, when viewed through the telescope W, appears to be in the centre of the mirror P, in which situation the line A B, as well as the axis of the telescope, will be situated in the plane of the true meridian.

The divided arc S is now to be moved, until the reflected image of the Moon, when viewed through the telescope W, is made to appear upon the horizontal centre line of the partially silvered mirror O; at which time the limb and vernier q is to be moved until the image of the Moon is brought to coincide with the reflected image of the Star in the mirror P, which will be seen above the silvered portion of the mirror O.

These operations being gone through, the Moon's meridian distance will be read off upon the divided arc Q by the vernier q , and her apparent declination upon the arc S by the vernier v .

Examples of the calculations for finding the longitude from the observed meridian distance of the Moon, and also from the observed declination, are given in the Appendix.

It frequently happens, that, in consequence of the horizon being obscured, the time at the place of observation cannot be ascertained, although the Latitude may be known; in this case, the apparent time may be found (independent of the horizon) by means of the

* The meridian distance of any known fixed Star may always be calculated from its right ascension.

observed meridian distance of a known fixed Star, as follows :—

The instrument must be placed North and South, in the same manner nearly as above described ; but with this difference, that, as the meridian distance of the Pole Star cannot (as in that case) be accurately computed, the observation must in this instance be taken about the time when the Pole Star appears to be stationary ; that is, when it is at its greatest elongation from the plane of the meridian ; the Star will then appear to remain stationary for two, three, or four hours. It is evident, therefore, that no great accuracy in setting the instrument to the exact meridian distance of the Pole Star is requisite ; and that, if the vernier r be *not* exactly set to its meridian distance at the time of observation, it will make no difference in the true position of the instrument ; when, therefore, the Pole Star is three, four, five, or six hours distant from the meridian, the vernier r may be set to the meridian distance (of the Pole Star), computed* from the estimated time, or the time by account. This being done, and the reflected image of the Star being viewed through the telescope W, as above described, the arc S and limb q are to be moved until the reflected image of the Star (whose meridian distance it is required to ascertain) is seen in the

* To find the Star's meridian distance nearly, subtract the Sun's right ascension (computed from the time by account) from the right ascension of the Star ; the remainder will give the time when the Star passed the meridian nearly : this time being subtracted from the time by account, will give the meridian distance of the Star with sufficient accuracy for the purpose abovementioned.

mirror O, and brought to coincide with that of the Pole Star. The Star's meridian distance will then be read off upon the divided arc Q by the vernier q .

The observed meridian distance of the Star thus found may be corrected for refraction, by the same rule as the correction for declination is calculated, (see the Appendix;) but of course no correction will be required if the observation be made on a Star near the zenith.

It is scarcely necessary to point out the uncertainty and difficulties which attend the practical application of the method of finding the longitude by the present Lunar Problem; requiring corrections for *two* altitudes, besides the observed distance: or the advantage and expediency of a method more accurate, less involved in abstruse calculations, and applicable in many cases when the present means cannot be used.

GENERAL DESCRIPTION OF PLATE II.

PLATE II. represents the Celestial Compass mounted in gimbals, as a means of detecting by simple inspection, as long as any of the Heavenly bodies are visible, the changes to which the magnetic needle is exposed in all parts of the world, in consequence of the local magnetism of the earth* or meteoric influence, independent of the local attraction of the iron of the ship, or the annual change of the variation of the needle. It serves also as a substitute for the magnetic compass in high Northern or Southern latitudes, where the directive power of the Magnetic Compass becomes almost useless from its feeble and uncertain action.

In many cases it is impracticable to calculate the variation, in consequence of the state of the sky or atmosphere precluding the observation for an amplitude or azimuth; the former can only be taken at the rising or setting, and the latter can only be taken with accuracy when the Sun or Star is at low altitudes. It will frequently happen, and particularly in the channels of the British Isles, that the horizon, and several degrees above it, is so obscured for some days together, that these observations cannot be made, although the sky is sufficiently clear at a greater altitude. In these circumstances no variation can be calculated with accuracy for

* Instances of the powerful effect which the local magnetism of the earth has upon the magnetic needle, are given in the Appendix, No. III.

those days, except from the Table of Variation, which is now becoming every day more and more uncertain. It is also to be observed, that, often, the detection of those accidents above mentioned (indeed almost always) depends on the observations, and may remain imperceptibly operating for a length of time, during which no observations to correct the variation can be had.

This construction of the Celestial Compass is also adapted for determining the Longitude when the Moon only is visible, the hazy state of the atmosphere generally intercepting the view of the Stars, although not sufficiently dense to obstruct that of the Moon, which even in cloudy weather may frequently be seen at intervals for a sufficient length of time to take an observation. In making use of the instrument for this purpose, the circular plate, with reflecting glasses, shewn in Figure I. Plate I. is to be substituted in place of that which is represented in Plate II.; but in this case, when the Stars are not visible, the instrument is to be placed true North and South by the magnetic needle, having *previously* ascertained its variation, and the local attraction, which may generally be determined with great accuracy by the means of the Celestial Compass above mentioned, by amplitudes, by azimuths of the Sun and Moon, with Mr. Barlow's recent ingenious but simple and complete method of shewing the quantity of local attraction of the iron of the ship.

Plate II. also represents the Celestial Compass adapted for ascertaining the Latitude when the horizon is obscured, or is rendered uncertain by refraction.

DESCRIPTION OF PLATE II.

Of the Celestial Compass as adapted for detecting by simple inspection, as long as any one of the Heavenly Bodies is visible, the Deviation of the Magnetic Needle. See Plate II.

A B represents the face or dial plate of the instrument ; this plate is screwed down upon the upper part of a box or case, C, of a hemispherical form. The hemisphere C is suspended upon pivots or axes at *c*, which work freely through holes formed in a metal ring D, and this ring is suspended upon pivots or axes at *d*, being situated at right angles with the pivots *c*, before-mentioned. The pivots *d* are adapted to turn in holes, or sockets, formed in adjustable bearings at the upper part of the two standards, or supports, E E ; and the feet of the standards are screwed down upon a plate of metal, F G, which is capable of revolving upon an axis in the centre thereof, affixed to the stationary platform, or board, H I.

The plate F G has the Cardinal points marked upon it, and is divided into degrees near its outer edge, being provided with a vernier I, affixed to the platform before-mentioned. K L represents a heavy plate of metal, which is suspended from the pivots or axes *c* by two brackets, or open arms, one only of which arms is seen in the Figure at M, the other being obscured by the hemisphere C.

The plate K L is situated considerably below the centre of gravity, or axis upon which the hemisphere C and ring are suspended, and thus tends always to

maintain the instrument in a plane parallel to the horizon.

The plate K L has an arm or limb rising up from it at K, the upper part of which is provided with a vernier *k*, adapted to read off the degrees upon a graduated arc, *g h*, engraved on the side of the hemisphere C.

The under surface of the plate K L is provided with two plane mirrors, or reflecting surfaces, *m m*, which are situated in a frame affixed perpendicular to the plate K L, but in such a position, that the reflecting surfaces form a salient angle with each other.

* These mirrors, by reflecting the horizon from two different parts, furnish the means of adjusting the instrument into a horizontal position when in use. For example: When any two parts of the horizon are reflected in the mirrors *m m*, if the instrument be moved until the images of these two parts appear upon the mirrors in one straight line, that line being at the same time parallel to the edges of the mirrors, will indicate that the plate K L, to which they are affixed, is horizontal †.

The pivots, or axes, upon which the hemisphere is suspended, project some distance through the ring D, and are furnished with small screw caps, which may be screwed on or off, for the purpose of giving the hemisphere a slight motion endways or in the direction of its axis, in order to adjust it into a proper position to balance correctly or horizontally in its gimbals.

* See Figure 7, Plate 3; also see the end of Appendix No. I.

† Another method of adjusting the instrument to a horizontal position, when the horizon is obscured, is given at the end of Appendix No. I.

The hemisphere C contains a weight or counterpoise within it, so situated that the centre of gravity should fall as nearly as possible in the centre of the hemisphere; or the centre of gravity should coincide as nearly as possible with the axis of its motion upon its pivot *c*, so that the horizontal position of the plate K L would not be disturbed by any turning or change of position of the hemisphere C upon its axis. The adjustment of its equilibrium may be performed by screwing up or down the small spherical weight Z, which is tapped upon a wire projecting from the top of the frame or tablet P.

In making use of the instrument for the purpose of finding the deviation of the magnetic needle, the direct light of the sun is made to fall upon a pair of cross wires, so as to direct their shadow upon a piece of ivory, marked with cross lines upon its surface, and the coincidence of the shadow of the cross wires with the intersection of the lines upon the ivory, will determine the required position.

The dial plate A B is divided into 24 hours, or 360 degrees, and is provided with an hour or index hand E, which is formed to a vernier at one of its extremities, to read off the degrees upon the dial plate.

P represents a small frame, or square, which is mounted upon a pillar on the hand E, and the axis of which is in the centre of, and perpendicular to, the dial plate. The frame P is adapted to receive a piece of ivory, *q*, having cross lines or wires, intersecting each other upon its surface.

The hour hand E has, near one of its extremities, a small pillar or tube *o* projecting up from it, and into

this tube a small round rod s is adapted to slide, having a square frame O at its upper extremity, furnished with cross wires, as represented in the drawing, Plate II.

The round rod s is graduated, and numbered with tangents to the angles of elevation or depression, above and below the level of the intersection of the cross lines upon the surface q , and it is provided with a vernier scale, formed on the side of the pillar o , to read off the divisions on the round rod. It is also furnished with a clamping and adjusting screw, as shewn in the Figure, to move it up or down with a slow motion.

Method of using the Instrument for ascertaining the variation of the Needle by Inspection.—See Plate II.

Suppose the platform $H I$ to be screwed upon the binnacle, or other convenient part of the ship, in such a position that the line $H I$, which is drawn upon the platform, may coincide exactly in a longitudinal direction with a line immediately over or parallel with the vessel's keel: now, if the hemisphere C be elevated upon its axes or pivots c , until the divisions upon the arc $g h$ are brought to read against the vernier k at the degree of the latitude of the place, it will be evident that the dial plate $A B$ will be situated parallel to the plane of the Equator, or perpendicular to the earth's polar axis. In this situation, if the hand or index E , be set to the apparent time, say three hours, or forty-five degrees from the meridian, as shewn in the Figure, and the rod s be elevated in the tube o to the division corresponding with the tangent of the Sun's declination, the compass plate, $F G$, which has the instrument mounted upon it, is then to be turned round upon its axis until

the shadow of the point of intersection of the cross wires O may fall upon the surface of the ivory q , so as that the said point of intersection may coincide with the intersection of the cross lines upon the surface q . The line A B or F G will then be in the plane of the true meridian, and the variation of the magnetic compass in the binnacle, or any other magnetic compass which is parallel to it, may be ascertained by inspection. In whatever course or direction the vessel may be proceeding, if the compass plate F G is turned upon its axis until the vernier I is brought to coincide with the point or degree corresponding with that course, the shadow of the intersection of the cross wires O should always coincide with the intersection of the lines upon the ivory q .

The vessel will then proceed in its course without deviation, the instrument serving as a constant and immediate check to the irregularities of the needle as long as any one of the Heavenly bodies is visible.

Method of using the Instrument for steering without Magnetic Aid.—See Plate II.

The dial plate A B is provided with watch-work, by which the hand E is moved round once in twenty-four hours.

Having fixed the platform H I over or parallel to the vessel's keel, and the hand E being set to the time, and the hemisphere C being set to the latitude, as above described, the compass plate F G, which has the instrument mounted upon it, is to be turned round upon its axis, until the zero of the vernier I is brought to coincide with such point or degree upon the compass

plate, as will correspond with the course desired to be steered. For example, in the drawing, the compass plate is represented as set proper for steering a course due North.

The person who steers the vessel has only to keep it in such a position that the shadow of the round rod *s*, or of the intersection of the cross wires *O*, may fall upon the surface *g*, so as to coincide with the perpendicular mark thereon. The line *A B* or *F G* will then remain in the plane of the true meridian, and the vessel will therefore proceed in a course due North. In like manner any other course may be steered, by setting the compass plate *F G* accordingly, and keeping the shadow of the rod *s* upon the perpendicular mark upon the surface of the ivory.*

This method of steering is particularly applicable to high Northern and Southern latitudes, as the Heavenly bodies remain constantly above the horizon, as long as navigation is practicable in those parts of the world, where the sky is generally unclouded and clear overhead; which circumstance is stated in Captain Lyon's late account of his unfortunate attempt to reach Repulse Bay, from which the following is an extract, viz.:

“ Although the fogs in the Polar Regions are so frequently mentioned in the course of recent narrations which have been published, I believe they are generally understood as resembling our English fogs;

* When the surface of the ivory cannot be distinctly seen by the person who steers, owing to its position with regard to the Sun, a piece of semi-transparent glass is used (in place of the ivory); the shadow is then seen behind the glass.

“ which is not, in fact, the case.—In the northern
 “ seas, these vapours rarely rise to above a hundred
 “ feet from the sea, and a sky of most provoking bril-
 “ liancy is frequently seen overhead.”—*Captain LYON’s*
Voyage of Discovery, page 43.

An instrument on the construction above-mentioned, for steering without magnetic aid, was ordered by the Lords of the Admiralty, and sent out with H. M. S. Hecla, on the Polar expedition, in the year 1824.

For ascertaining the Latitude when the Horizon is obscured.—See Plate II.

The platform H I being fixed over or parallel to the vessel’s keel, as above described, the instrument is to be turned upon the axis or pivot of the compass plate F G, until *o* on the outer division is brought to coincide with *o* on the vernier I. The round rod *s* is to be set to the Sun’s declination as above described, and the line F G is to be placed North and South, by means of the magnetic compass in the binnacle.* The hemisphere C is then to be inclined upon its axis *c*, and the hand E moved, until the shadow of the intersection of the cross wires O is brought to coincide with the intersection of the marks upon the surface of the ivory *q*; the vernier *k* will then indicate the latitude of the place, by means of the divisions upon the arc *g h*.

In like manner, the apparent time may be obtained when the latitude is given, by setting the arc *g h* to the latitude, the rod *s* to the Sun’s declination; the hand E is then to be moved until the shadow of the intersection

* Of course the variation must be allowed for.

falls upon the cross lines upon the ivory q , as before described. The vernier at the end of the hand E will then indicate the apparent time, even when the horizon is obscured, and when an altitude cannot therefore be taken.*

Method of using the Instrument for finding the Moon's Meridian Distance and Declination, when that object only is visible.—See Plate II.

In making use of the instrument (as represented in plate II.) for the purpose of finding the Moon's meridian distance and declination, when that object only is visible, and when the hazy state of the atmosphere intercepts the view of the Stars, the circular plate, with reflecting glasses, as shewn in Figure I. Plate I. is to be substituted in place of that which is represented in Plate II. and it is to be screwed down upon the hemisphere C in the same manner.

The hemisphere C is to be set to the latitude of the place as before described. The instrument is to be turned round upon the axes or pivots of the plate $F G$, until the o in the outer divisions is brought to coincide with o on the vernier I .

The instrument is then to be placed true North and South, by the aid of the magnetic compass in the binnacle (having previously ascertained its variation), in which position the helmsman is to keep the vessel as

* As the method of adjusting the instrument to a horizontal position by means of the reflecting mirrors, $m m$, cannot be used when the horizon is obscured, another mode of adjustment, by means of the Sun's declination, is given at the end of Appendix No. I.

steady as possible during the time of taking the observation. By means of another magnet needle placed in the centre of the plate K L (not shewn in the figure), the part of the instrument which is suspended in gimbals, may be placed more accurately in the plane of the meridian, by turning the large milled-headed screw at the top of the upright E.

The divided arc S is to be moved until the reflected image of the Moon, when viewed through the telescope W, is made to appear upon the centre of the mirror O. The Moon's meridian distance will then be read off upon the divided arc Q, by the vernier q , and her declination upon the arc S by the vernier v . Although the same degree of accuracy cannot be expected in this method of observing the Moon's meridian distance and declination, (the instrument being suspended in gimbals), as by means of the reflecting instrument represented in Figure I. Plate I. the former not being so independent of the motion of the ship as the latter, yet, from the precision with which it may be adjusted to a horizontal position, (means of indicating which adjustment are already described,) and its capability of maintaining that equilibrium, notwithstanding the change of position of the hemisphere C upon its axis, it is presumed that a considerable degree of accuracy may be expected; but should it not be found capable of attaining extreme accuracy, still, even an approximation to the true meridian distance and declination is very important, when *the Moon only is visible*, there being no other means so accurate of determining the longitude by that *object alone*.

GENERAL DESCRIPTION OF FIGURE II. PLATE I.

FIGURE II. Plate I. represents the Celestial Compass adapted for surveying, by means of the Heavenly bodies, without using a magnetic needle, which is now found to be inefficient for that purpose when a survey of large extent is to be taken, in consequence of its irregular action; the deviation of the needle being different in different places at the same time, and different in the same place at different times; besides the uncertainty arising from local attraction of mountains charged with iron ore, &c.* It is therefore difficult to connect an extensive survey by means of the magnetic needle, and hence the necessity for a minute series of triangles and trigonometrical calculations, by which such inaccuracies are only partially corrected. This construction of the Celestial Compass is also adapted (as a portable instrument) for the purpose of taking bearings of objects by means of the Sun or a Star, at any time one of these objects is visible; as also of ascertaining the Latitude when the horizon is obscured; and it may be used in the hand in the manner of a box sextant. The instrument on this construction was furnished to Captain Franklin, R. N., on the land Polar expedition, in the year 1825.

* Instances of the effects of the local magnetism of the earth on the needle are mentioned by Captain Franklin, R. N., in the account of his journey to the Polar Sea; see Appendix, No. IV.: as also in Murray's Tour to the Hebrides; see Appendix, No. IV.

DESCRIPTION OF FIGURE II.—PLATE I.

The instrument consists of an index or dial plate A B, which is divided into 24 hours or 360 degrees. This dial plate is mounted upon pivots or axes, which pass through holes or bearings in a metal ring D, so as to admit of moving therein; and the degree of angle at which it may have been placed is determined by an arc $g h$, which is graduated with degrees, and is adapted to read off the degrees upon a vernier k affixed to the ring D. The dial plate A B is furnished with an index or hour hand E, one extremity of which is formed to a vernier to read against the degrees upon the dial plate A B.

The hand E has also a small tube or pillar o , rising up from it, into which a small graduated rod s slides, and is formed at the upper extremity to a square frame O, having cross wires as represented in the drawing.

P represents a small square of ivory, having cross lines or wires upon its surface; the ring D has a groove or circular channel turned out in its face, into which channel a second ring F G is inserted, with liberty of turning round freely therein.

The ring F G is provided with a vernier adapted to read off the degrees upon the ring D, and it has two sights, W w , having joints in them at about the middle of their length, for enabling them to be folded down into a compact form for the convenience of carriage; but when this instrument is intended for accurate sur-

veys, it is made on a large scale, having a telescope instead of sights, and the index plates similar to those of the theodolite, and mounted upon a tripod stand.

The outer circumference of the ring D is cut with a screw, and is adapted to have a box screwed over it, so as to form a cover for the instrument when not in use. The box also serves to screw on beneath the plate D, the manner of ordinary box sextants, so as to serve for holding the instrument by, when used in the hand, or fixing upon a small portable stand as represented in the Figure.

Method of using the Instrument.

In making use of this instrument, in order to find the bearing of any object, the index or hour hand E is to be set to the apparent time, suppose three o'clock, or 45 degrees from the noon hour line A B.

The dial plate A B is to be inclined upon its pivots or axes *c*, in the ring D, until the divided arc *g h* reads off, against the vernier *k*, the degrees corresponding with the latitude of the place; the small rod *s* is now to be raised out of the tube *o*, until the divisions upon it are brought to correspond with the tangent of the angle of the Sun's declination, the rod being divided for that purpose. This being effected, the instrument is to be moved into such position, that the shadow of the point of intersection of the cross wires O may fall upon the ivory, so as that the said point of intersection of the cross wires may coincide with that of the cross lines upon the ivory P, at which time the surface of the ring D will be situated truly horizontal, and the

line A B upon the dial plate, as well as the North and South line upon the ring D D, will be situated in the plane of the true meridian.

The ring F G, and sights W *w*, (or telescope), are now to be turned round, until the object, the bearing of which is desired to be ascertained, when viewed through the slits or apertures in the sights, appears to be intersected by the perpendicular wires in the sights; in which situation the true bearing of the object may be ascertained by inspection of the vernier attached to the under part of the sight *w*, by reading off the degrees upon the ring D. A small reflecting mirror is placed at about the part *w*, being on the inside of that sight which is turned towards the object, in order that the coincidence of the shadow of the point of intersection of the cross wires in the square frame O, with the intersection of the lines upon the tablet P, may be observed distinctly by reflection; at the same time that the observer might have his eye placed to the sights for viewing the object.

On the same principle the latitude may be ascertained by inspection, when the horizon is obscured, and at any time the Sun or a Star is visible. For this purpose, the instrument being placed upon its stand, the index or hour hand E is set to the apparent time,* and

* The apparent time may be obtained in a known longitude from the mean time, subtracting or adding the equation of time according as the Sun is fast or slow in coming to the meridian; but when the longitude, and consequently the mean time, is not known, the instrument may be placed in the meridian by the magnetic compass, allowing for the variation.

the rod s to the declination of the object as before ; the ring DD is then to be placed horizontal, by means of a spirit level in the usual manner. The dial plate AB , is then to be inclined upon its pivots or axes c , in the ring D , until the shadow of the point of intersection of the cross wires O is brought to coincide with the intersection of the cross lines upon the ivory, as before mentioned, at which time the degree on the arc gh , which is found to correspond with the vernier k , will shew the latitude of the place by inspection.

APPENDIX.

No. I.

THE following is the principle upon which the Celestial Compass is constructed, viz. :

The apparent motion of the Sun being caused by the uniform rotation of the Earth upon its axis from West to East, once in twenty-four hours, it will appear evident, that, if an arm be moved with an equable motion in a contrary direction to the apparent motion of the Sun, and having its axis of motion in a position parallel to the Earth's axis,* the arm would keep pace with the apparent motion of the Sun, while it describes its horary angle ; if, therefore, the time be given, and the arm be set to that time, and be directed towards the Sun, the noon hour line would then be situated in the true meridian.

For example, see Figures IV. and V. Plate III.

Let O P represent the arm, A F G, a circle described about its axis P, and divided into twenty-four equal parts or hours. When the arm O P is set to the apparent time, suppose three hours, or 45° from the meridian, the instrument is then to be turned so as to bring the arm in a line between the axis P and the Sun S. The arm will then, by its motion, continue to perform the same horary angle as the sun appears to describe, and A P, being the noon hour line, will therefore always indicate the true meridian.

In like manner, the true meridian may be indicated by means of a Star, by calculating its distance from the plane of the meridian, or its horary angle at the time of observation, and setting the arm accordingly.

* The Earth, seen from the Sun, would appear but as a point, and the centre of motion of the arm may therefore be considered as coinciding with that of the Earth.

As the relative position of the Sun or a Star, with regard to the plane of the meridian, may be determined as above, its declination may also be determined as follows:—See Figure V. Plate III.

Let Figure V. Plate III. represent the exact position of the sphere, having its axis $P P$ elevated to the latitude of the place, and the arm $O o$ set according to the apparent time, suppose three hours, or 45° from the meridian, and directed to the Sun S .

The meridian distance of the Sun S , or the angular distance between the plane of the arm $O o$ in that position, and the noon hour line $A P$, will be equal to forty-five degrees, because the instrument, being an exact representation of the position of the Earth, having the axis P parallel to the pole, and the noon hour line $A P$ parallel to the plane of the meridian, the horary angle is the measure of the meridian distance of the object S . In like manner, a line $E Q$, which is perpendicular to the axis $P P$, or to the Pole, will be parallel to the plane of the Equator, with which it will continue to maintain the same relative position during the motion of the arm $O o$ round its axis $P P$.

As the arm $O s o$ is an arc of a circle of which P is the centre, therefore, when the object has no declination, it will appear in the direction $E Q$, or the line $S O P$ will coincide with the line $E P Q$. But when the object S declines from the Equinoctial, the measure of its declination will be shewn by the part of the arc $O s o$ which is above $E Q$, of which arc the sight at P is the centre. The curve $O s$ having a sight at O , is movable within the fixed part of the arm o , and may be raised or lowered so as to bring the sight at O in a line between the object S and the other sight at P .

The fixed part of the arm at o is graduated from each side of o ; the vernier upon the movable curve at o will indicate the amount of the angle of elevation or depression of the sight O ,

above or below $E Q$, which angle is equal to the apparent declination of the object S at the time of observation. For example, in the Figure, the sight O is ten degrees above the Equinoctial line $E Q$, because the vernier placed upon the movable curve is ten degrees higher than o on the index of the fixed part of the arm. On the contrary, if the sight O were below the Equinoctial line $E Q$, the vernier would be depressed in the same proportion below o on the index. The declination will of course be shewn, not only for noon and midnight, but for any intermediate time, and therefore the quantity of increase or decrease for any given time will also be shewn.—See Figure III. Plate I. A further example is given by Figure III. Plate I., which represents the oblique position of the sphere of which M is the centre, $E Q$ the Equator, $n m$ a parallel of declination of the object S , $P S P$ a circle of declination at the given time, suppose three hours, or forty-five degrees from the meridian. The arc $S d$, equal to the arc $E n$, is also the measure of the angle $d M S$ or $E M n$, the angle formed by the plane of the Equator and $M n$, or equal to that formed by the line $E Q$ of the instrument and the ray $O P$ of the object S .

Method of adjusting the Instrument to a Horizontal Position, by means of the Declination of the Object.—See Figure V. Plate III.

When the Instrument is set in its position by means of the Sun or a Star, either of these objects itself will indicate when the instrument is truly horizontal: for this purpose the arm being previously set to the angle of the declination of the Sun or Star, and also to the apparent time, if the sight O , is then found to be in a line between the object S and the other sight at P , it will be evident the bottom of the instrument or socket M will be parallel to the plane of the horizon.

APPENDIX.—No. II.

EXAMPLE 1.

Of finding the Longitude by means of the observed Meridian Distance or Horary Angle of the Moon.

ON the 17th October, 1824, in latitude $51^{\circ} 22' 30''$, at 22H. 45M. 15s. A. M. (previously ascertained by an observation as before described in page 5.) Suppose the observed meridian distance of the Moon to be $43^{\circ} 32' 59''$.

Required the longitude?

	H.	M.	S.
Apparent time at place of observation	22	45	15
☉ Right Ascension corrected* . .	13	28	56
Right Ascension of the Meridian . .	36	14	11
	24		
	12	14	11
▷ Meridian distance in time corrected†	2	59	59
▷ Right Ascension in time . . .	9	14	12
	60		
	4)554		
▷ Right Ascension in degrees . .	138	33	00
▷ R. A. at Greenwich, midn. of Oct. 16	132	17	40
	6	15	20 1st difference.

* The Sun's right ascension may be corrected by the longitude by account. A few degrees of longitude would not affect the result.

† The observed meridian distance will require a correction on account of parallax and refraction, which may be found in the same manner as an error

- D R. A. at Greenwich, noon of 17th Oct. 139 10 55
 D R.A. at Greenwich, midnight, 16th Oct. 133 17 40

6 53 15 2d difference.

As $\overset{\text{H.}}{6^{\circ} 53' 15''} : 12 :: \overset{\text{H.}}{6^{\circ} 15' 20''} : \overset{\text{H.}}{10} \overset{\text{M.}}{53} \overset{\text{S.}}{55}$
12

22 53 55 Time at Greenwich.
22 45 15 Time at place of
 observation.

Answer, Longitude in time 8 40 = $\overset{2}{2}^{\circ} 10'$ West Long.

in time corresponding with a given error in altitude is determined, viz. from the latitude, azimuth, and altitude of the object. For example :

Suppose the latitude $51^{\circ} 22' 30''$
 Azimuth 59 31 33
 Error in altitude . . . 46 46

Then the hour angle or error in time = 46 46

Nat. cos. of lat. $51^{\circ} 22' 30''$ $\times$ nat. line of azimuth $59^{\circ} 31' 33''$

Hence the error in time = 5M. 48s. or $1^{\circ} 26' 55''$ to be added to the observed meridian distance.

For the demonstration of this problem, see Appendix VII.

N. B. By knowing the error in altitude, the corresponding error in time may be readily found, as follows, by a simple proportion, (without the preceding calculation,) viz. as $46' 46''$ is to 5M. 48s. so is any given error in altitude, to its corresponding error in time.

EXAMPLE 2.

Of finding the Longitude by means of the observed Declination of the Moon.

On the 17th of October, 1824, in latitude $51^{\circ} 22' 30''$ North, at 22H. 45M. 15s. A.M. apparent time (previously ascertained by an observation taken as before described in page 5.) Suppose the observed declination of the Moon to be $11^{\circ} 44' 15''$, and her altitude (either observed or *computed*) to be $35^{\circ} 56' 42''$.

Required the Longitude?

▷ Apparent altitude	$36^{\circ} 43' 28''$	Observed declination	$11^{\circ} 44' 15''$
Correction . . .	$46 46$	Correction* . . .	$35 4$
True altitude . . .	$36 43 8$	True declination . . .	$12 19 19$
			90
		Polar distance	$77 40 41$

* The observed declination will require a correction on account of parallax and refraction, which may be thus found, viz. See Figure 8, Plate 3.

Let ZP = co. latitude.

ZS = the true co. altitude.

ZM = the apparent co. altitude.

SM the correction for the altitude is found by the tables in the usual manner.

SN the correction for declination is found as follows :

Let SO be parallel to NM.

Then will MO be equal to SN, the correction of declination required.

In order to find the side MO, the angle SMO or ZMP must first be found thus :

Let Zm be perpendicular to MP.

In the solution of the spherical triangle ZmM, the segment Mm, and consequently the angle ZMP or SMO, is found.

Hence in the triangle SOM, are given

	The angle SMO
The correction of altitude	SM
And the right angle	SOM

From which data the side MO is found, which is equal to SN, the correction for declination.

N. B. In each latitude the correction for declination bears a regular proportion to the correction for altitude: for example, in latitude 20° , the correction for declination is one-fifth of the correction for altitude; in latitude 51° , it is three-fourths, and in latitude 60° , it is eight-ninths.

Tables may therefore be calculated, from which the required correction for declination may be found by inspection, *without* calculating the spherical triangle.

Latitude . . . 51° 22' 30" Secant 0.204617
Polar distance . . . 77° 40' 41" Co-secant 0.010121

2)165 46 39

Half sum . . . 82 53 14 Co-sine 9.092801
Remainder . . . 46 9 46 Sine 9.858121

2)19-165660

22 29 57 Sine 9.582830
8

Meridian distance . . . 2 59 59

Apparent time at place of observation . H. M. S.
☉ Right ascension corrected * . 13 28 56

Right ascension of the meridian . 36 14 11
24

⋔ Meridian distance . . . 12 14 11
2 59 59

⋔ Right ascension in time . . . 9 14 12
60

4)554

⋔ Right ascension in degrees . . . 138° 33' 00"
⋔ R. A. at Greenwich, midn. of 16th Oct. 132 17 40

6 15 20 1st difference.

⋔ R. A. at Greenwich, at noon of 17th Oct. 139° 10' 55"
R. A. at Greenwich, midn. of 16th Oct. 132 17 40

6 53 15 2d difference.

As 6° 53' 15" : 12H. :: 6° 15' 20" : 10H. 53M. 55S.
12

Time at Greenwich 22 53 55
Time at place 22 45 15

Longitude in time . . . 3 40 = 2° 10' W. Answer.
Longitude.

* The Sun's right ascension may be corrected by the longitude, by *account*; a few degrees of longitude will not affect the result.

APPENDIX.—No. III.

Extract from Captain Parry's Voyage of Discovery in the year 1823.

“THE information obtained by Captain Lyon, on his late journey with the Esquimaux, served very strongly to confirm all that had before been understood from these people respecting the existence of the desired passage to the westward, in this neighbourhood, though the impossibility of Captain Lyon's proceeding further in that direction, combined with our imperfect knowledge of the language, still left us in some doubt as to the exact position of the Strait in question: it was certain, however, that it lay somewhere in that direction to which we had been already so long and so anxiously looking, and that its eastern entrance was still occupied by many miles of fixed and therefore impenetrable ice; but the very impediment that had arrested Captain Lyon's progress, as well as our daily observations on the state of the ice near its outer margin, appeared to offer a considerable hope that this obstacle must in the course of nature very soon disappear, even by the gradual process of dissolution, if it were not more speedily removed by one grand and total disruption.

“While, therefore, Captain Lyon was acquainting me with his late proceedings, we shaped a course for Igloolik in order to continue our look-out upon the ice, and made the tents very accurately by the Compass, after a run of five leagues, when the Hecla hauled in shore to pick up one of her men that had been left there to procure game, and the Fury stood towards the margin of the ice. Just before we reached off the floe,

the weather continuing extremely thick, with hard rain, I desired Mr. Crozier to set the extremes of the loom hanging over Igloodik, which was then on our lee quarter. He did so, but presently afterwards remarked that the compasses (both Walker's azimuth, and Alexander's steering) indicated the ship's head to be S. W. which was about the middle point on which, but a few minutes before, he had set the loom of the land two or three points abaft the beam. Knowing, by the true direction in which we were sailing, that the ship's course by the compass, if unaffected by any foreign local attraction, should have been about East, which in fact the needles had indicated previous to the change remarked by Mr. Crozier, I tried what tapping with the hand (the usual expedient in cases of mere sluggishness) would do, but without producing any effect. Being now obliged to tack for the ice, we carefully watched the compasses in standing off, and having sailed about a quarter of a mile, observed them both return gradually to their correct position. Being thus satisfied that some extraordinary local attraction was influencing the needles, we again tacked to repeat the experiment, and with a nearly similar result. The observations were then continued on one or two successive tacks, the ship being steadily steered upon a given point, by some object a-head; and an account of the whole is subjoined in one connected view. The observations were made between six and nine P. M. The wind being moderate at East (true,) the weather very rainy, the soundings fifty-two fathoms, and the nearest land distant from six to eight miles.

“The space sailed over during the time the changes were taking place, did not exceed a quarter of a mile.

Starboard

“Starboard Tack, compasses first indicating the ship's head East, then changed to South West.

Larboard N. W. b. N. S. W. $\frac{1}{2}$ W.
Starboard East S. S. E.

Bore away to endeavour to cross our original track.

Larboard tack { Alexander's compass N. W. b. N. . W. b. S.
Walker's N. W. W. S. W.

Starboard, both compasses East S. W. $\frac{1}{2}$ S.

Larboard { Alexander's... N. W. $\frac{3}{4}$ N. S. W. b. W. $\frac{3}{4}$ W.
Walker's.... N. W. S. W. b. W. $\frac{1}{4}$ W.

Starboard tack, both compasses N. E. b. E. $\frac{3}{4}$ E. .. E. $\frac{3}{4}$ E.

Alexander's, a minute or two after, returned to N. E. b. E. $\frac{3}{4}$ E. and Walker's to E. $\frac{1}{2}$ N. Alexander's compass was placed on the binnacle, the other stood about five feet higher, in its usual place.

“In order to follow up the observations on this phenomenon on some other day, I sent a boat to fix a flag upon the ice, by way of marking the spot, but the margin was so broken up that it was impracticable to land upon it; a light buoy was therefore moored for the same purpose, though with little chance of retaining its station, on account of the depth of water. During the remainder of the night, when the wind and weather obliged us to keep more to the northward, the compasses were not thus influenced. *

“The weather cleared up in the morning of the 2d. We found that a strip of ice about half a mile in width had been lately separated from the fixed ice, but this to our impatience appeared like a drop of water in the ocean; con-

* The spots near which this local attraction was found, are designated on the Chart by this mark, $\oplus$.

siderable streams and patches were also drifting along the margin during the day, and we were employed in breaking through them in order to make fast to the floe, the weather being unfavourable for keeping under way. In the evening we secured the ships to the ice, being in twenty-three fathoms, at the distance of two miles to the westward of Tern Island. For several hours in the course of this day there was something in the atmosphere which distorted objects into very curious shapes. The principal feature in this phenomenon was a constant waving tremulous motion near the horizon, causing the whole body of ice to appear at times as if turning round, and making one almost giddy to look steadfastly at it. The distant land was sometimes flattened down so as to appear like a single thick black line upon the horizon; then again it would assume a shape of this kind—

when its real outline, when not thus distorted, was this,—

“The tremulous appearance is, in a greater or less degree, a very common phenomenon in the Polar Seas. Such, indeed, is the frequent occurrence of extraordinary and variable terrestrial refraction, and the consequent uncertainty with respect to the dip of the horizon, that observations made by the horizon of the sea, even when wholly free from ice, cannot be depended on within two or three minutes. There is, how-

ever, practically, little or nothing to regret on this account, from the almost constant opportunities that occur in these seas of resorting to the more accurate method of observation by artificial horizons. The weather, which had for several hours been rainy and thick, cleared up about noon on the 4th. In consequence of the wind shifting to the N. W. we made sail from the floe, in order to look for the buoy and to continue our observations on the magnetic attraction in that neighbourhood. After making several tacks as near the place as the bearings of the land and the soundings could direct us, but without discovering the buoy, we were obliged for the present to give up the attempt; having to our great satisfaction observed a floe, at least three miles in length and two in breadth, just detached from the fixed ice, and rendering it necessary for us to work out of its way lest it should force us towards the shore: we only, therefore, waited to put down some nets to ascertain the nature of the bottom, and then hauled round the floe. A quantity of shells, among which were a few of the new species of *Anomia* discovered on the last voyage, with some shrimps and echini, were all that we could thus fish up. Having cleared the end of the floe, which drifted rapidly away, and, as usual here, never made its appearance afterwards, we made the ships fast to the fixed ice P. M. having by the late disruption made considerable progress in the direction of the Strait."

Page 317.—"The wind gradually falling, was succeeded by a light easterly breeze, with which, at daylight on the 26th, we steered under all possible sail up the Strait. The course being shaped, and no ice in our way, I then went to bed; but was immediately after informed by Mr. Crozier that the compasses had shifted from $N \frac{1}{2} E.$, (which was the course I left them indicating) to $E \frac{1}{2} N.$, being a change of seven points in less than ten minutes. After running half a mile in a true W. by N. direction, the needles began to return to their

true position ; in half a mile farther they had resumed their proper direction, and agreed exactly at North. Having sent a boat to the Hecla immediately on our noticing the first alteration, I found from Captain Lyon that a similar phenomenon was observed to take place on board that ship, which was following in our wake. The breeze slowly increasing from the eastward, and the weather happily remaining unusually clear for that direction of the wind, we soon arrived off the narrow part of the Strait ; immediately on opening which, we met a tide or current running above two knots to the eastward, with numerous eddies and rippings. By keeping on the South, or continental shore, and passing along by Cape N. E. within two or three hundred yards of the rocks, we succeeded, with the assistance of the boats a-head, in getting through the channel soon after eleven o'clock."

Extract from Captain Lyon's Voyage of Discovery.

Latitude $61^{\circ} 13'$ —Longitude $63^{\circ} 54'$.

"The deviation of our compasses was here very great and irregular, although less so with our head northward, than otherwise : even Gilbert's excellent azimuth compass required constant tapping, although under the influence of Professor Barlow's plate, which had hitherto corrected it with the greatest accuracy."—Page 30.

"The stillness of this day was highly favourable for obtaining observations for the dip of the needle ; but the floe to which we were fast was not of sufficient extent to admit of our getting so far from the ship as to be free from her attraction : I was now the more desirous of obtaining these observations, on account of the fast increasing sluggishness of the compasses,—for that of Gilbert's, which had hitherto been fully corrected for the local attraction of the ship by Barlow's

plate, now began to shew nearly as much deviation when our head was to the eastward, as any of the other compasses.”—Page 44.

“Our compasses had now become quite useless, with our head southerly; and that in particular to which the plate was fitted, so powerless, that its North point stood wherever it was placed by the finger; but with our head northerly, they all traversed again. This, however, benefited us but little; for, as our route lay to the South West, we were without other guidance than Celestial bearings, which could not always be obtained.”—Page 53.

“In the forenoon watch, our larboard compass, which, with two others, had shewn our head N. b. W. which (with three points and a half westerly variation) agreed with the Sun’s bearing, in giving a N. W. $\frac{1}{2}$ W. course, suddenly pointed E. N. E., and no tapping or motion would keep it in any other point for two or three minutes; after which, it as suddenly recovered its agreement with the others, and continued quite correct. We now, from repeated observations, discovered that when our head was nearly North by compass, the deviation was three points and a half West; but when between North and West, it amounted to eight points; while with the head to the Southward, the compasses would generally rest wherever they were directed by the finger; and sometimes each persisted in maintaining a direction of its own.

“Barlow’s plate now became useless, and its want of effect was decided by finding Gilbert’s compass, while under its immediate influence, the dullest in the ship.”

Ellis, in his account of the Expedition of the Dobbs and California, in 1746, says:—

“I cannot help taking notice in this place (while off Chesterfield Inlet), while amongst these islands, and in sailing through the ice, the needles of our compasses lost their mag-

netical qualities: one seeming to act from this direction, and another under that; and yet they were not for any considerable time constant to any. We laboured to remedy this evil, by touching them with an artificial magnet, but to very little purpose; for if they recovered their powers by this means, they presently lost them again."—ELLIS's *Account*, page 220, in the year 1748.

“Although the fogs in the Polar regions are so frequently mentioned in the course of the recent narrations which have been published, I believe they are generally understood as resembling our English fogs, which is not in fact the case. In the Northern seas, these vapours rarely rise to above a hundred feet from the sea, and a sky of most provoking brilliancy is frequently seen overhead.”—LYON's *Voyage*, page 43.

APPENDIX.—No. IV.

Extract from Captain Franklin's Journey to the Polar Sea.—1819.

“*August 12th.*—Azimuths were obtained this evening that gave the variation $58^{\circ} 45' 0''$, which is greater than is laid down in the Chart, or than the officers of the Hudson's Bay ships have been accustomed to allow. Latitude 57° North.”
—Page 26.

“*August 19th.*—Nothing worthy of remark occurred, except the rapid decrease in the variation of the magnetic needle.

“N. B. At York factory the variation is only $6^{\circ} 00' 21''$ East.”—Page 32.

“*September 25th.*—About half a mile from the bend or knee of the lake, there is a small rocky islet, composed of magnetic iron ore, which affects the magnetic needle at a considerable distance. Having received previous information respecting this circumstance, we watched our compasses carefully, and perceived that they were affected at the distance of three hundred yards, both on the approach to and departure from the rock; on decreasing the distance, they became more and more unsteady; and on landing they were rendered quite useless, and it was evident that the general magnetic influence was totally overpowered by the local attraction of the ore. When Kater's compass was held near to the ground on the North West side of the island, the needle dipped so much that the card could not be made to traverse by any adjustment of the hand; but on moving the same compass about thirty yards to the West part of the islet, the needle became horizontal, traversed freely, and pointed to the magnetic North. The dip-

ping needle being landed on the South West point of the islet, was adjusted as nearly as possible on the magnetic meridian, by the Sun's bearings, and found to vibrate freely: when the face of the instrument was directed to the East or West, the mean dip it gave was $80^{\circ} 37' 50''$; when the instrument was removed from the North West to the South East point, about twenty yards distant, and placed on the meridian, the needle ceased to traverse, but remained steady at an angle of 60° ; on changing the face of the instrument so as to give it a South East and North West direction, it hung vertically. The position of the slaty strata of the magnetic ore is also vertical,—their direction is extremely irregular, being much contorted.”—Page 56.

“The observations of this evening seem to corroborate the remark which I had previously made, that the direction in which the needle moves seems to depend upon the position in which the streams of the Aurora Borealis are placed, and the quantity of its effect to its proximity to or distance from the earth. When the extremities of the arches lay near the bearings of 324° and 54° , the needle moved eastward; and when near the bearing, 324° and 144° , or 279° or 99° , the motion of the needle was westward: both of these facts were shewn to-night. At the first display, when the extremities of the arches pointed near 234° and 54° , and the interior motion followed the same direction, the needle moved eastward as far as 345° , but after midnight, coruscations ceased to appear in that direction, and at $12^h 10^m$, were presented in three arches traversing the zenith, whose extremities pointed 121° and 302° ; the needle then receded towards the West, and rested at $349^{\circ} 30'$, having varied its position $5^{\circ} 40'$ in the course of twenty minutes.”—Page 560.

“I apprehend much of the irregularity in the result of the observations for the variation of the compass along the Copper Mine River is to be attributed to local causes of attraction,

and particularly to the existence of iron ore among the rocks, which is very general: a greater intermixture of iron ore was perceived in the rocks on the sea coast, than on the banks of the Copper Mine River.”—Page 635.

“The seat of the phenomenon of the Aurora Borealis lies between the latitudes 64° and 65° North, or about the position of Fort Enterprize, because the coruscations were as often seen there in the southern as in the northern parts of the sky.”—Page 553.

The Island of Canna, on the western coast of Scotland, affords a remarkable instance of the effects on the magnetic needle from the local attraction of mountains (charged with iron ore.)—See MURRAY’S *Tour to the Hebrides*.

Fig. 1.

Fig. 1.

Fig. 2.

Fig. 3.

*A Celestial Compass for taking Bearings without Magnetic Aid.
Furnished to Capt. W. Franklin R. N. for the use of the Land Polar Expedition in the year 1825*

Compass for
Admiralty; and

APPENDIX.—No. VI.

The following Problem, for computing the Error in Time corresponding to a given Error in Altitude, is selected from Gregory's Trigonometry.—See Figure VI., Plate III.

Let N M be a portion of the Equator, P the elevated Pole, S o a portion of the parallel of declination in which the heavenly body is on the day of observation; and let o be the real, and r the apparent place of the body, or o r the error in altitude; draw S r parallel to the horizon; from Z the Zenith, draw Z S Z o; and from P the Pole, the meridians P S N, P o M, to pass through S and o, and cut the Equator N M; then S and o will be the apparent and real places of the body on the parallel of declination; and the arc S o, in that circle, or N M on the Equator, will measure the angle S P o, the corresponding error in time.

The triangle S r o, being of course exceedingly small, may be regarded as a rectilinear triangle, right angled at r:

Hence $r o : o S :: \text{Sine of } r S o : \text{radius}$

and $s o : N M :: \text{Cos. of } M o : \text{radius.}$

Consequently, by multiplying the corresponding terms, we have, $r o \times S o : S o \times N M :: \text{Sine of } r S O \times \text{Cos. } M O : \text{radius,}$ or rejecting S o from the first and second terms, $r o : N M :: \text{Sine of } r S o, \text{Cos. } M O : \text{radius.}$

Whence $N M = r o \frac{\text{rad}^2}{\text{Sine of } r s o \text{ Cos. } M o.}$

But $Z o P = r s o, r o s$ being the complement of each, and $\text{Sine } Z o P (= \text{Sine } r S o) : P Z :: \text{Sine } o Z P : \text{Sine } P o.$

Consequently $r S o$, $\text{Sine } P o = \text{Sine } r S o$, $\text{Cos. } M o = \text{Sine } P Z$,
 $\text{Sine } r Z P$. Therefore by substituting for the denominator
 in equation 1, its equivalent in the last, we have

$$N M = \frac{o r \text{ rad)}^2}{\text{Sine } P Z \text{ Sine } o Z P} = \frac{o r}{\text{Cos. lat. Sine } o Z P} \text{ or } N M = \text{error in time.}$$

$$\text{or the error in time} = \frac{o r, (\text{error in altitude.})}{\text{Co sine lat. Sine of azimuth.}}$$

APPENDIX.—No. VII.

A Comparative Statement of the Change of the Moon's Right Ascension in a given time, with the change of her Angular Distance from the Sun or a Star during the same time. For the Year 1824.

Date.	Difference of Moon's Right Ascension between Noon and Midnight.	Star's name.	Difference of Moon's Angular Distance between Noon and Midnight.	Difference between Right Ascension and Angular Distance during the same time, or during 12 hours.
March 9	7° 41' 35"	Sun	6° 31' 44"	1° 9' 51" R. A.
—	—	Arietis	7 00 46	0 40 49 R. A.
—	—	Regulus	7 1 37	0 39 50 R. A.
20	6 55 8	Sun	5 47 15	1 7 53 R. A.
—	—	Formal	5 41 45	1 13 23 R. A.
26	5 35 8	Sun	5 24 16	0 10 52 R. A.
—	—	Antares	5 56 32	0 20 24 Ang. Dis.
Sept. 26	7 14 27	Sun	6 17 6	0 56 19 R. A.
—	—	Aquila	5 57 14	1 17 11 R. A.
Oct. 13	7 17 47	Sun	5 9 9	1 7 38 R. A.
—	—	Regulus	6 38 47	0 39 0 R. A.
Nov. 25	6 5 54	Sun	5 34 26	0 31 28 R. A.

LONDON:
PRINTED BY S. AND R. BENTLEY, DORSET-STREET.